

1 radiant burner surface area and the excess combustion  
2 air operating air ratio is controlled in the range of  
3 30% to 100% (wherein the excess air ratio is defined as  
4 percent combustion air in excess of the stoichiometric  
5 amount required for complete combustion of the burner  
6 fuel) to prevent overheating of the surface of the  
7 radiant burner and to prevent overheating of the  
8 premixed fuel and oxidant contained within the burner  
9 core. In the present invention, the reactant mass  
10 velocity is controlled in the range of 400 lb/ft<sup>2</sup>/h to  
11 1500 lb/ft<sup>2</sup>/h in order to limit the reaction chamber  
12 tube wall temperature to the desired range of 1300°F to  
13 1500°F.

14 Combustion products emanating from the  
15 permeable metal fiber zone 14 enter the inlet 13  
16 leading to the convection chamber 17, wherein the  
17 combustion products exchange heat with tubular reaction  
18 chamber 1 for preheating the feed to leg 1b.

19

## 20 **EXAMPLE**

21

22 A compact endothermic catalytic reaction  
23 apparatus according to the preferred embodiment was  
24 constructed and tested. The reaction chamber consisted  
25 of 1 inch schedule 40 pipe constructed of 310 stainless

1 steel that was formed in a U-tube arrangement spaced on  
2 3 inch centers. The reaction chamber was packed with a  
3 commercial steam reforming catalyst that was crushed  
4 and screened to an average particle size of  
5 approximately  $\frac{1}{4}$  inch.

6 The radiant burner consisted of 4 inch long  
7 by 1  $\frac{1}{2}$  inch outer diameter cylindrical assembly that  
8 had an active radiant angle  $\gamma_1$  of 120 degrees. The  
9 burner assembly was placed in an insulated combustion  
10 chamber having dimensions of 6 inch internal diameter  
11 and 10 inch height. The radiant burner assembly was  
12 spaced approximately 4 inches from the U-tube  
13 centerline. The convection chamber consisted of a 2  
14 inch tube constructed of 304 stainless steel.

15 The radiant burner was fired using a mixture  
16 of propane and air at a total higher heating value  
17 firing rate of 12,000 btu/h. The reactant mixture  
18 consisted of 1 lb/h of propane and approximately  
19 3.5 lb/h of steam and was fed to the reaction chamber  
20 at a temperature of approximately 800°F. The reactant  
21 mixture was heated in the reaction chamber to an exit  
22 temperature of 1250°F. The measured tube wall  
23 temperature of the reaction chamber was 1450°F, the  
24 radiant burner surface temperature was 1750°F, and the  
25 combustion products exit temperature was 1050°F. The

1 estimated hydrogen plus carbon monoxide yield was 67  
2 SCFH.

3

4 Fig. 3 depicts another embodiment of the  
5 present invention. In this embodiment, a radiant  
6 burner surface 30 having a hemispherical geometry  
7 radiates energy to the reaction chamber like that of  
8 Fig. 1. A mixture of fuel and oxidant enters the  
9 radiant burner from an inlet conduit 31. The  
10 longitudinal axis of the inlet conduit is oriented  
11 normal to the plane of the U-tube reaction chamber.

12 Fig. 4 depicts yet another embodiment of the  
13 present invention. In this embodiment, the reaction  
14 chamber is defined by a volume enclosed by a tubular  
15 reactor conduit comprising an upper section 19  
16 consisting of a vertically disposed tube that is  
17 connected to the inlet means 2, a lower section 20  
18 consisting of a helical coil, having an outer diameter  
19 between 6 and 36 inches, and an exit section 21  
20 consisting of a vertically disposed tube that is  
21 connected to an exit means 3. The upper section 19 of  
22 the tubular reactor conduit passes concentrically  
23 through the convection chamber 17. The reaction  
24 chamber is packed with catalyst from the inlet means 2,  
25 where reactants enter, to the outlet zone 22 of the